Retrieval of Time-Varying Land Cover and Vegetation Properties from MODIS in Support of the NCEP-WRF Land Surface Model

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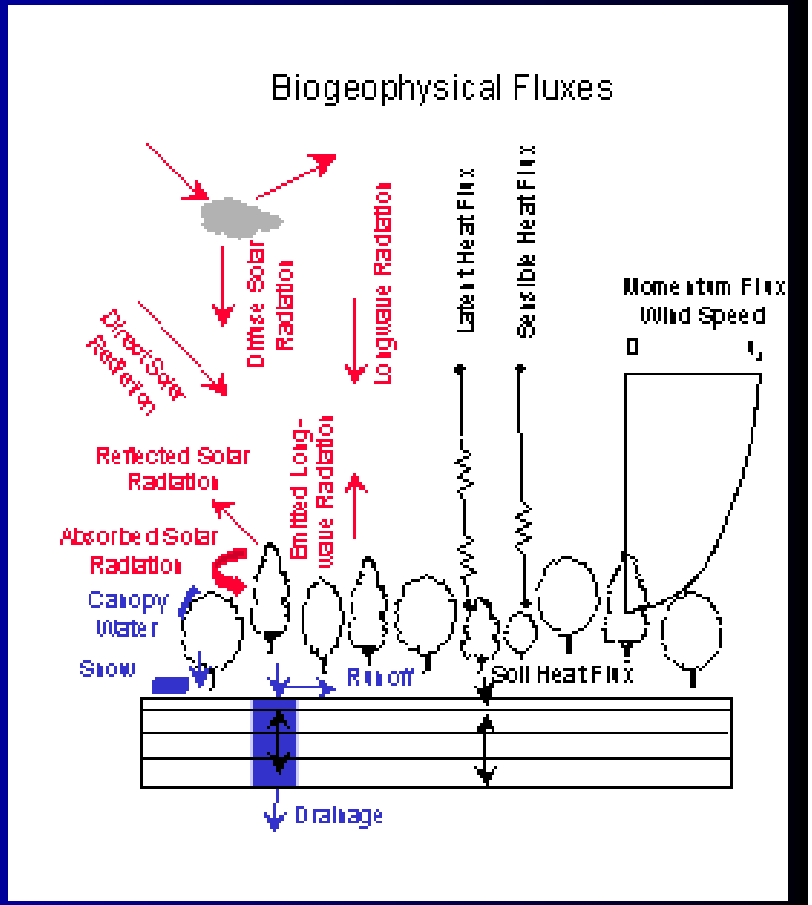
Context

- Improved basis for land surface parameterization
  - MODIS
  - NCEP land Model
- Variables of Interest
  - Pseudo-static
    - Land Cover (UMD)
  - Time Varying
    - Fractional vegetation cover
    - Albedo; LAI

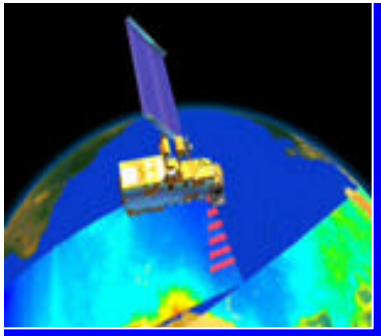


Project Objectives

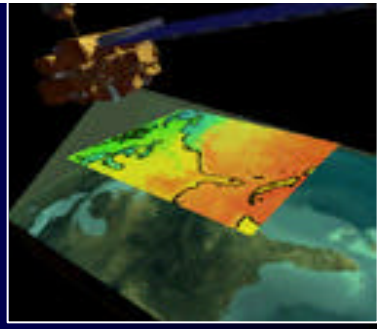
- Two projects
  1. Current: 1 year, prototype data sets and methods
  2. Future: 2- year transition towards operational retrieval
- Four main goals:
  1. Develop land surface representation in which multiple sources of remote sensing inputs are portrayed in an internally consistent manner (including sub-grid stats).
  2. Develop methods to retrieve F_v from MODIS
  3. Develop methods for near-real-time retrieval of surface property suite from MODIS in support JCSDA
  4. To quantify differences in land surface properties from MODIS vs AVHRR vis-à-vis influence on NCEP land model
- Prepare for NPOESS Era

Outline

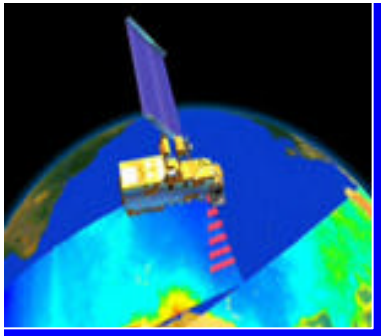
1. Background on MODIS
   - Instrument
   - Overview of data used to characterize land cover and land cover dynamics
   - Standard products vs needs for assimilation in NWP models
2. Project activities
   - Land cover and fractional vegetation cover
   - Development of tools/data sets for spatial aggregation of land surface data



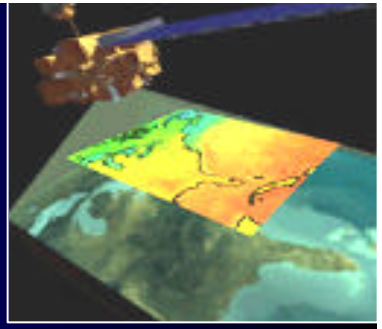
1. Background



- MODIS
  - Moderate Resolution Imaging Spectroradiometer
- Onboard EOS-Terra and EOS-Aqua
  - 10:30 AM (descending); 1:30 PM (ascending) local solar equatorial crossing
- Sun-synchronous, near polar orbit; 705.3 km



MODIS Instrument Characteristics



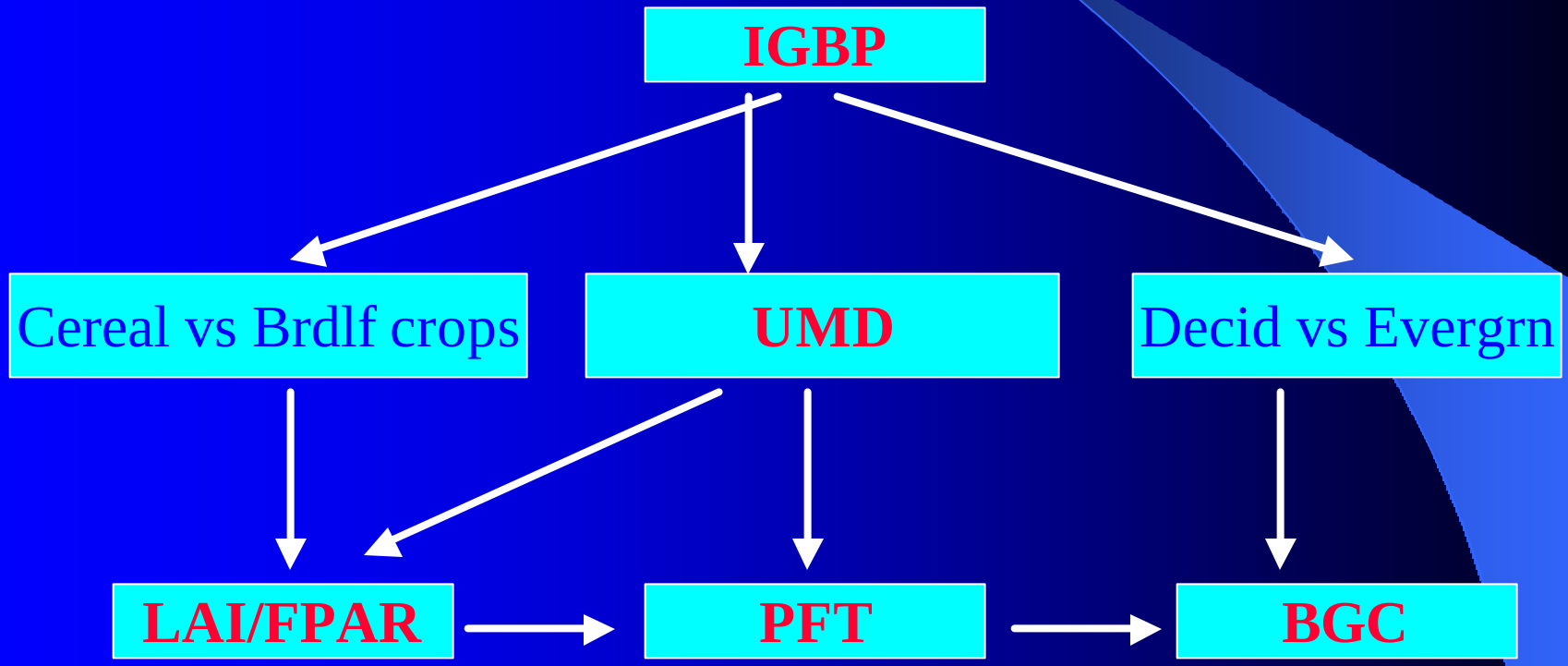
- MODIS Instrument Characteristics
  - 36 spectral bands, VNIR, SWIR, TIR (0.4–14 ?m)
  - Spatial resolutions at 250-, 500-, and 1000-m (nadir) depending on waveband
  - Scan angle: ±55°; 2330 km swath
  - 2-day global repeat, 1-day or less poleward of 30°
  - Onboard calibration; Band-to-band registration, etc.
  - Improvement over heritage (AVHRR)

MODIS Land Bands

Band number	Spatial resolution	Wavelength, nm	Waveband region
1	250 m	620-670	Red
2	250 m	841-876	Near-infrared
3	500 m	459-479	Blue
4	500 m	545-565	Green
5	500 m	1230-1250	Near-infrared
6	500 m	1628-1652	Shortwave infrared
7	500 m	2105-2135	Shortwave infrared

Current efforts all use 1 km nadir BRDF adjusted reflectances.
Future efforts will use 500 m NBARS data, once available.

MODIS Global Land Cover Database Internally Consistent Maps (MOD12Q1)



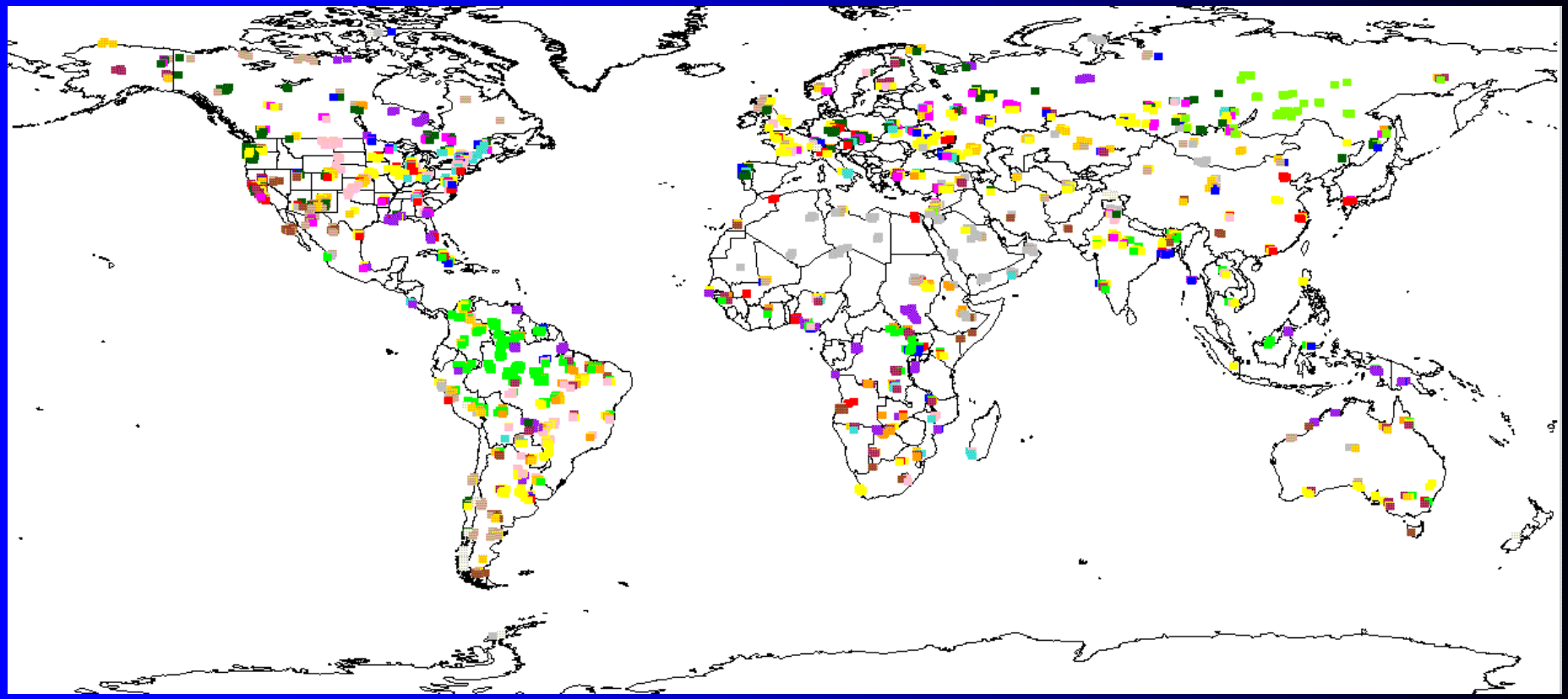
UMD: University of Maryland

LAI/FPAR: Leaf Area Index/Fraction Absorbed Photsynthetically Active Radiation

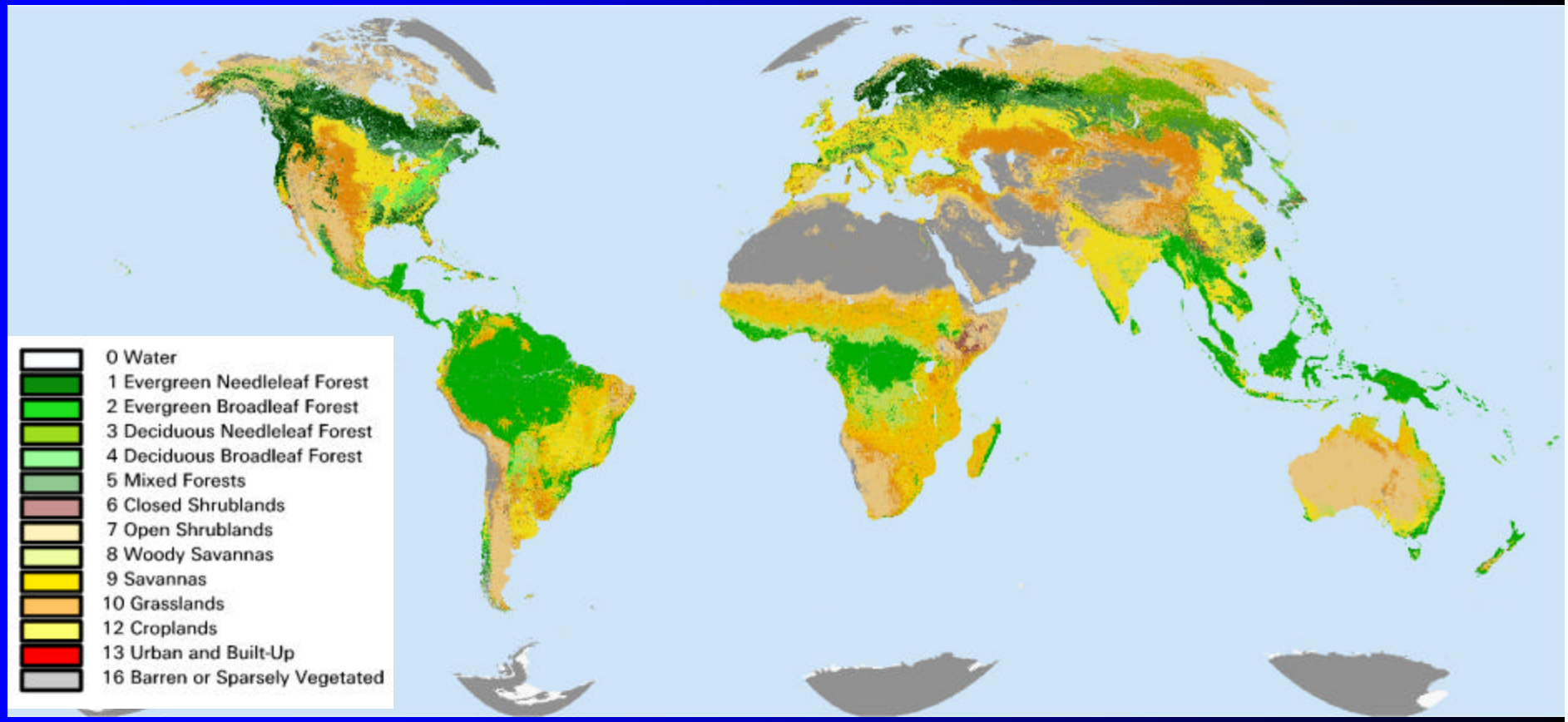
PFT: Plant Functional Types; **BGC**: Biome BGC

Global Sampling and STEP Maintenance

Database of ~2000 sites interpreted from Landsat and ancillary data including biophysical characterization

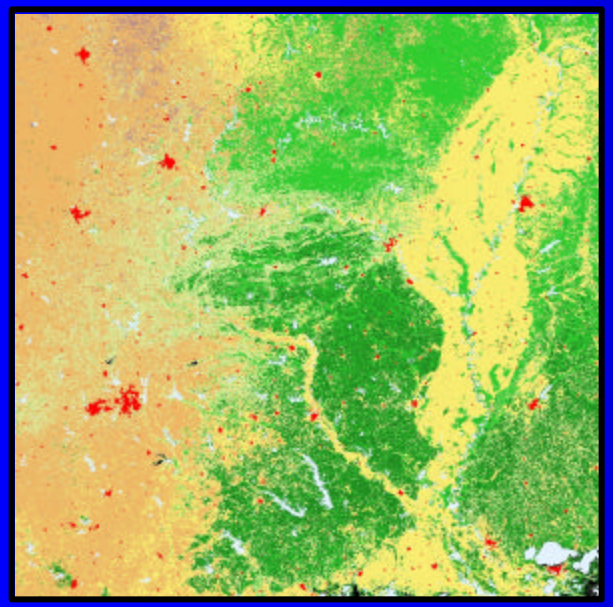


Sample Layer: UMD



Regional View

LAI/FPAR

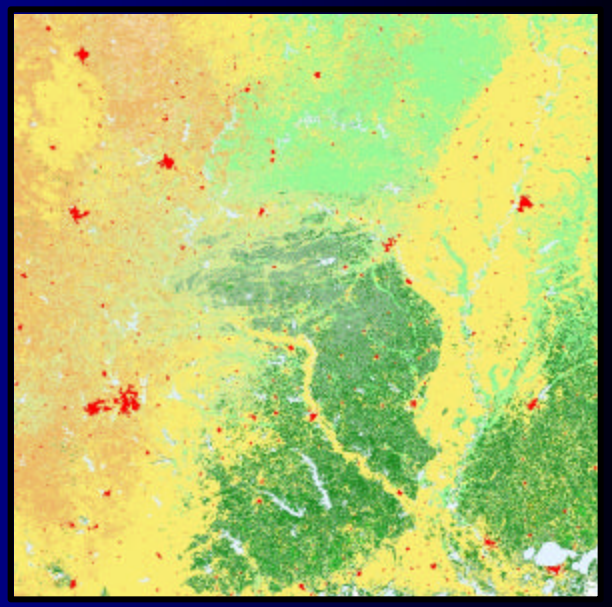


- Water
- Grasses/Cereal
- Shrubs
- Broadleaf crops
- Savannah
- Broadleaf forest
- Needleleaf forest
- Unvegetated
- Urban

Plant Functional Types

- 0 Water
- 1 Evergreen Needleleaf Tree
- 2 Evergreen Broadleaf Tree
- 3 Deciduous Needleleaf Tree
- 4 Deciduous Broadleaf Tree
- 5 Shrub
- 6 Grass
- 7 Cereal crop
- 8 Broadleaf crop
- 9 Urban and built-up
- 10 Snow and ice
- 11 Barren or sparsely vegetated

UMD



- 0 Water
- 1 Evergreen Needleleaf Forest
- 2 Evergreen Broadleaf Forest
- 3 Deciduous Needleleaf Forest
- 4 Deciduous Broadleaf Forest
- 5 Mixed Forests
- 6 Closed Shrublands
- 7 Open Shrublands
- 8 Woody Savannas
- 9 Savannas
- 10 Grasslands
- 12 Croplands
- 13 Urban and Built-Up
- 16 Barren or Sparsely Vegetated

Project Activities: 1. Land Surface Properties and Spatial Aggregation

Toolkit development

- MODIS data being produced at 1 km
  - Moving to 500m in next couple of years

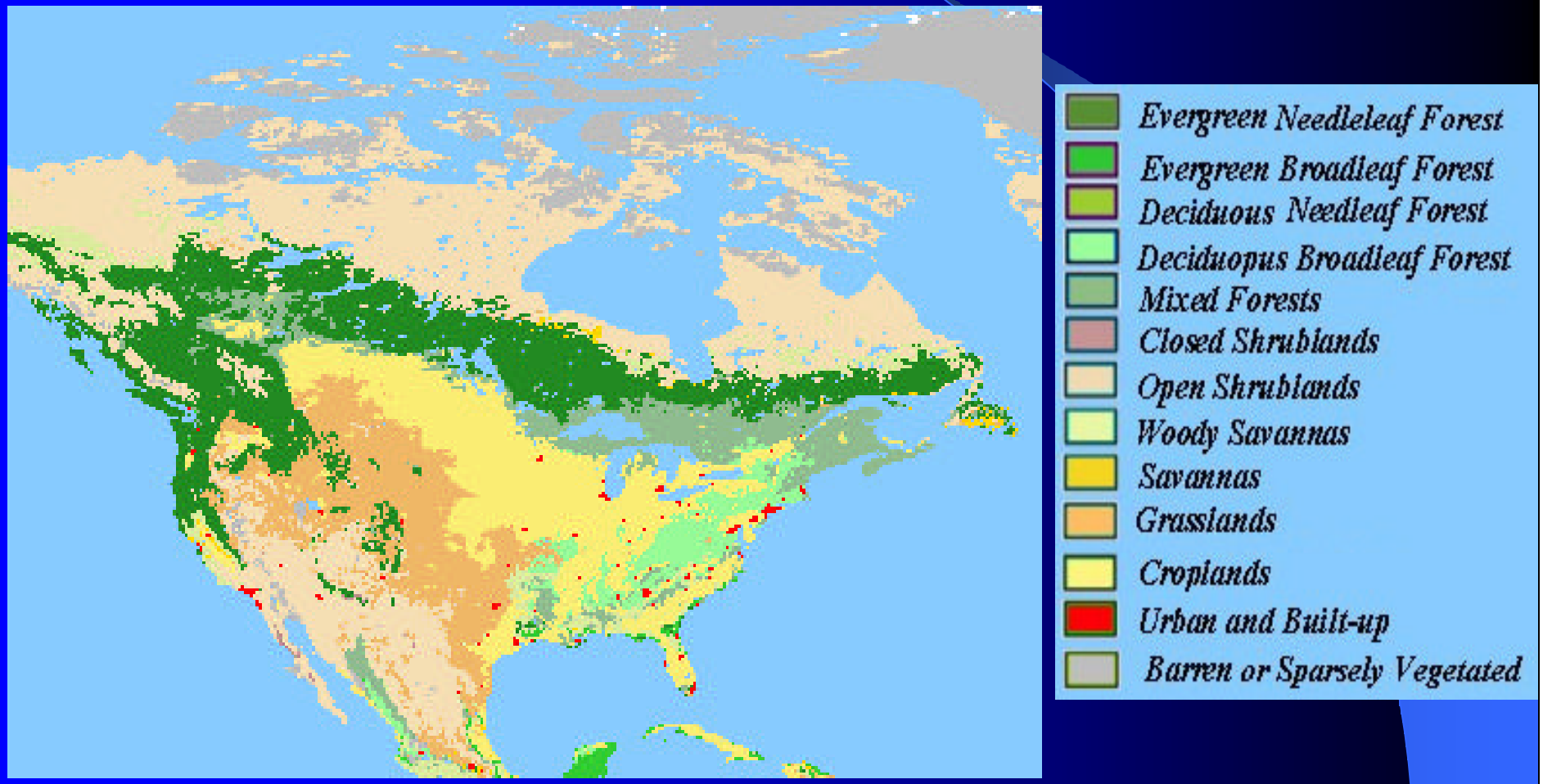
Objective

- Software to spatially aggregate 1 km data to arbitrary spatial resolution
- Retaining sub-grid statistics by class
  - Min, max, mean standard deviation, area (km^2)
- Variables include: land cover, LAI, albedo, fractional vegetation cover

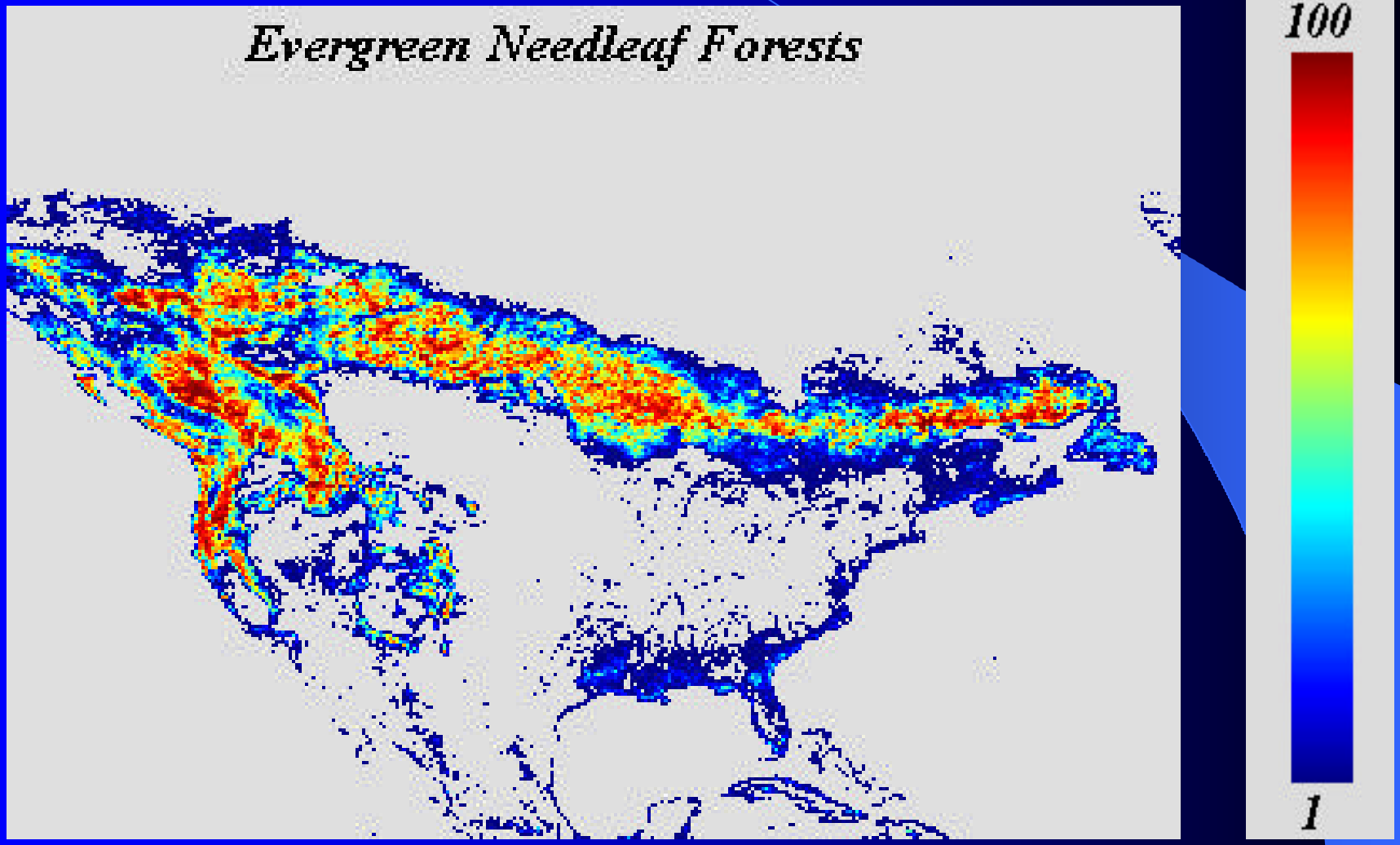
Land Surface Variables

- Land Cover
  - 14 class system defined by UMD
- Albedo
  - White sky, black sky, SZA @ solar noon
  - Broadband solar, VIS, Solar IR
- Leaf Area Index
- Fractional vegetation
  - Total vegetated area (F_v); green vegetated area (F_g)
- Prototype: North America

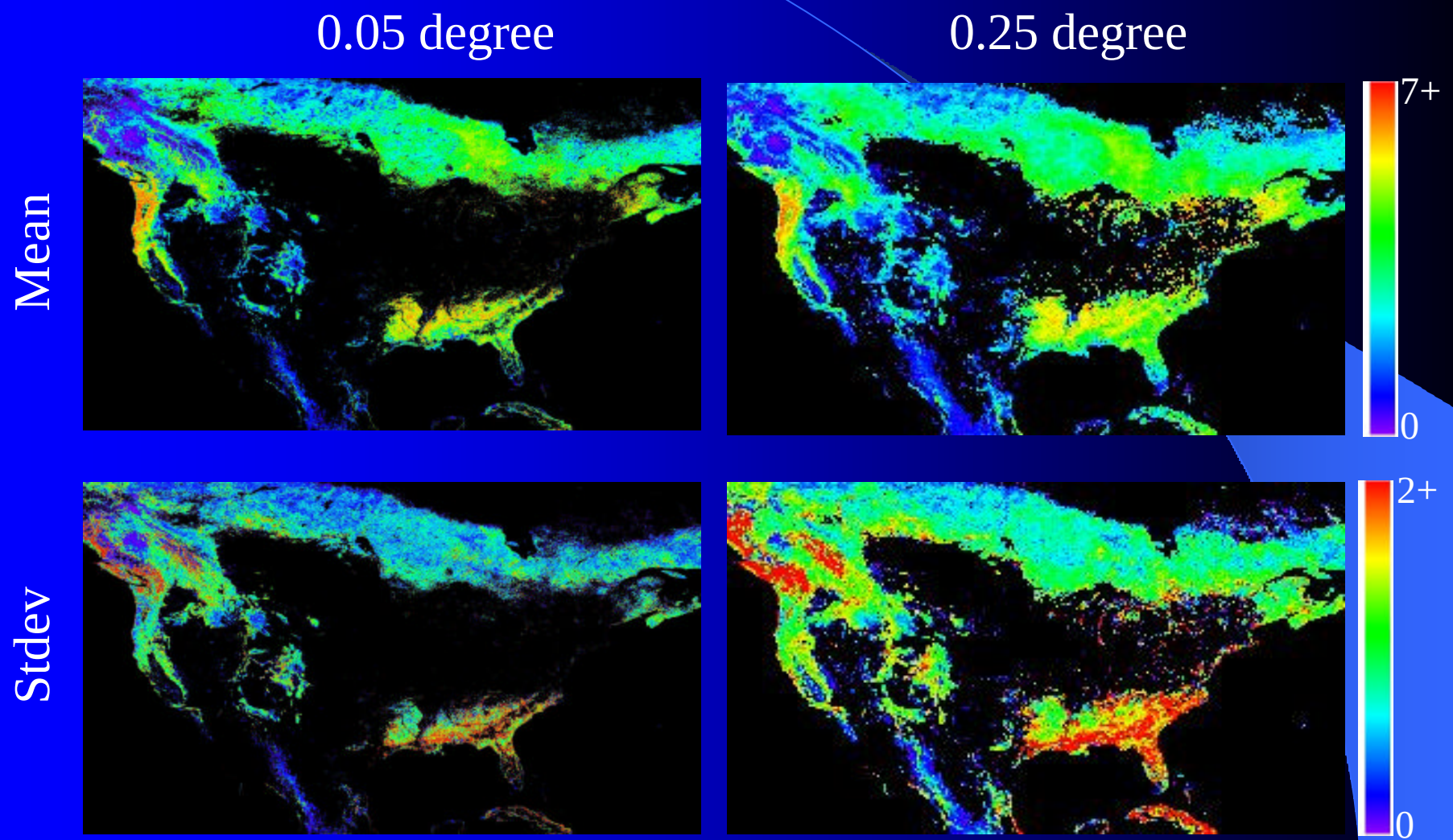
Prototype: North America, UMD Land Cover (0.25º)



Sub-Grid Percentage of Each Land Cover Type



LAI Subgrid for Evergreen Needleleaf Forest (May 25 - June 1, 2001)



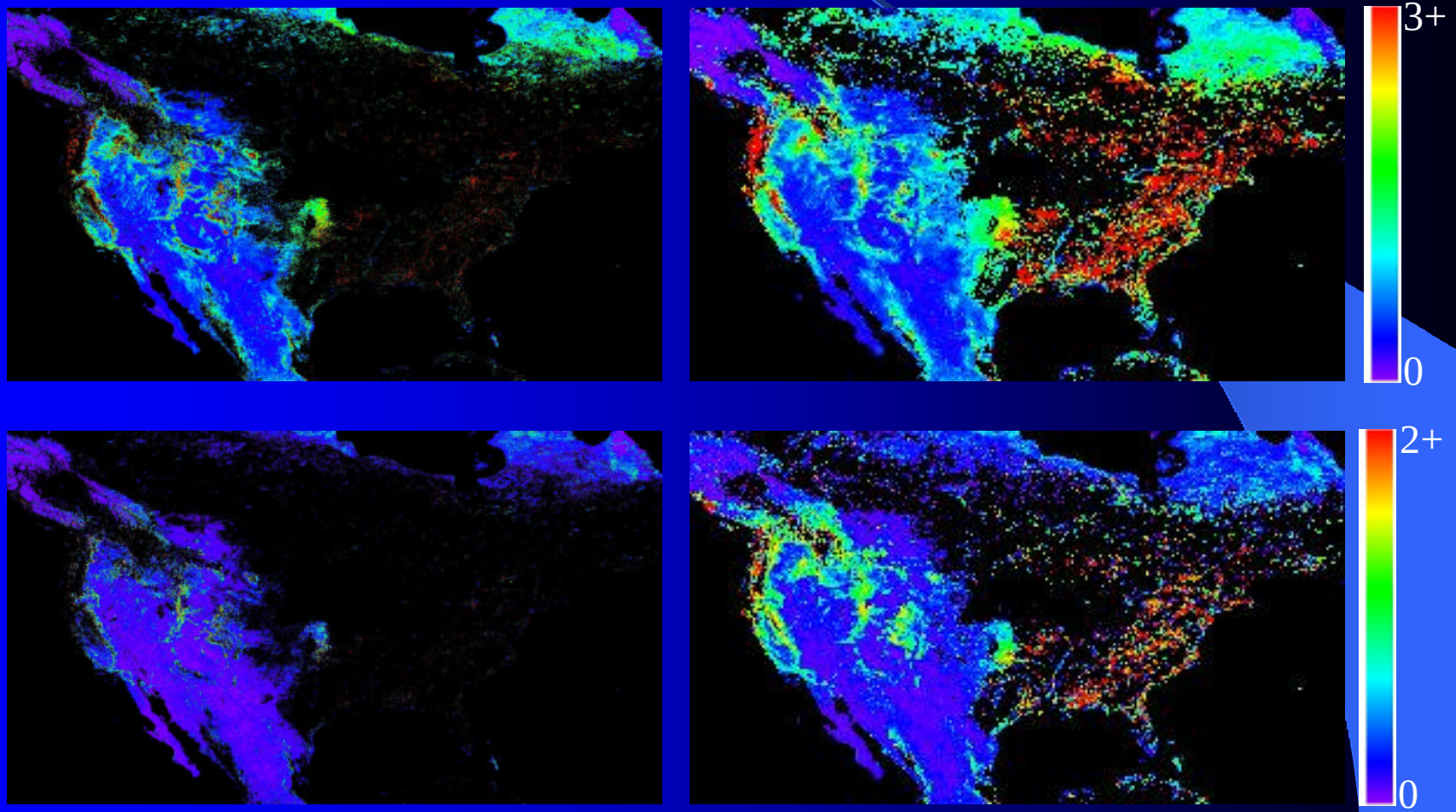
LAI Subgrid for Open Shrublands
(May 25 - June 1, 2001)

0.05 degree

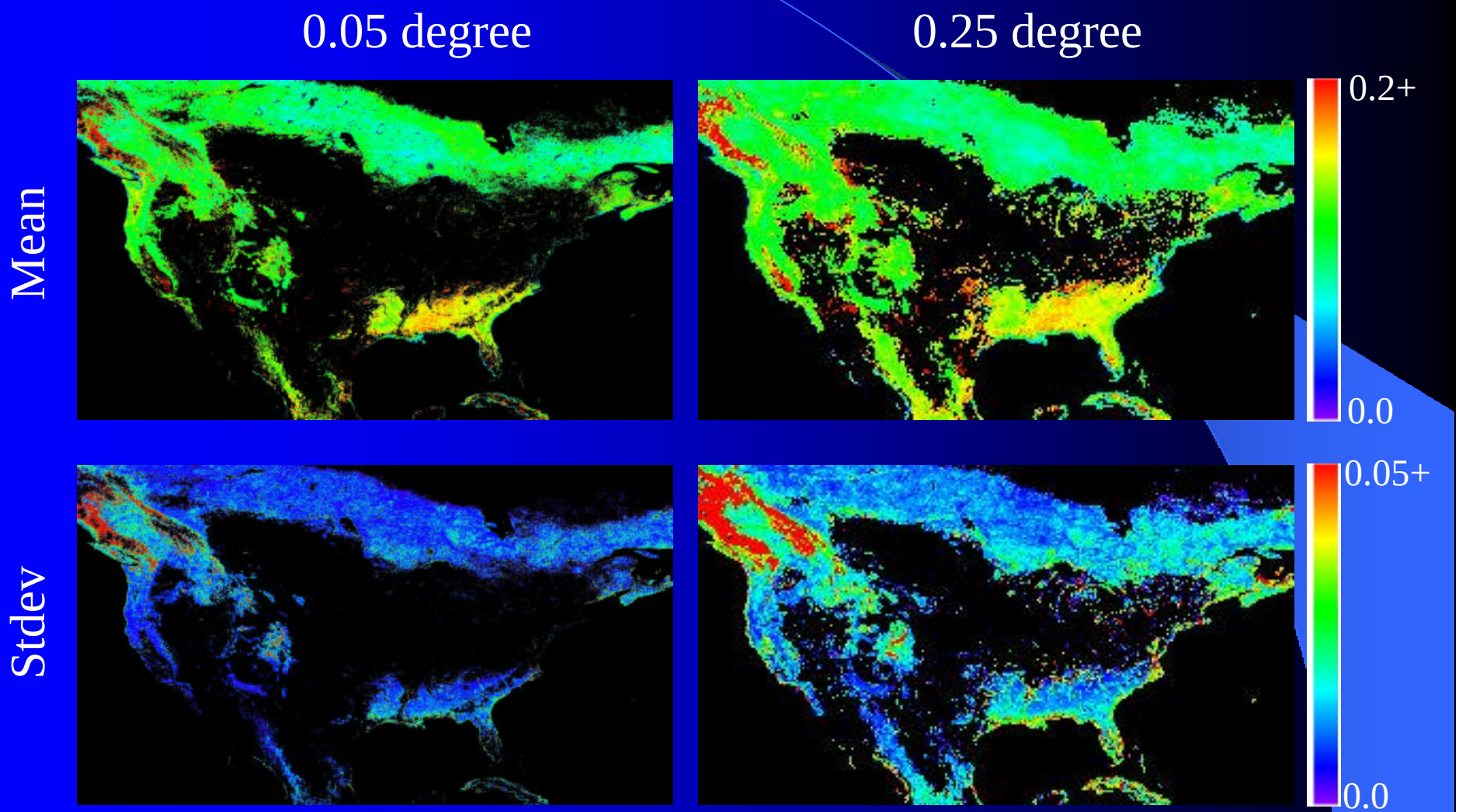
0.25 degree

Mean

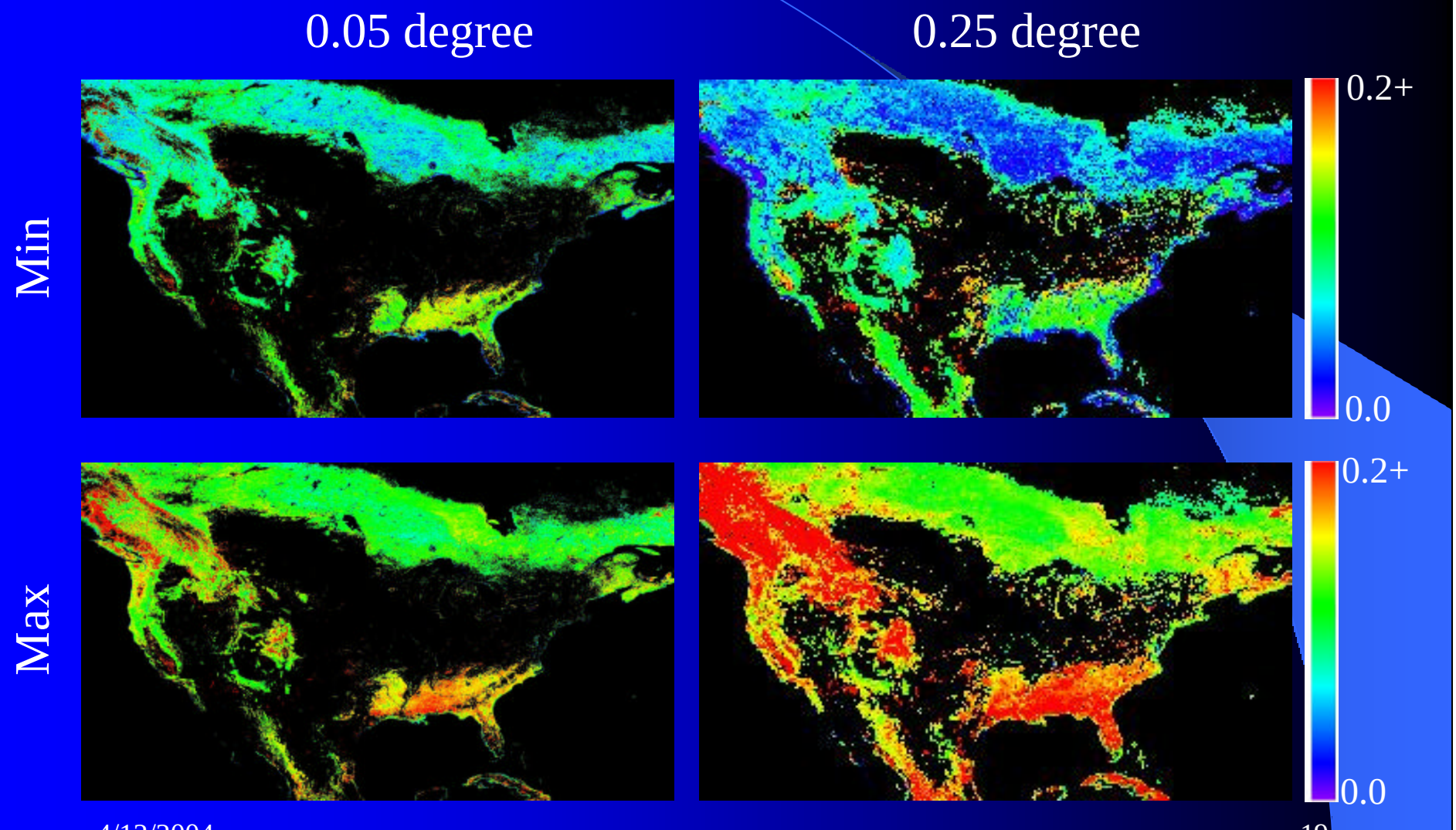
Stdev



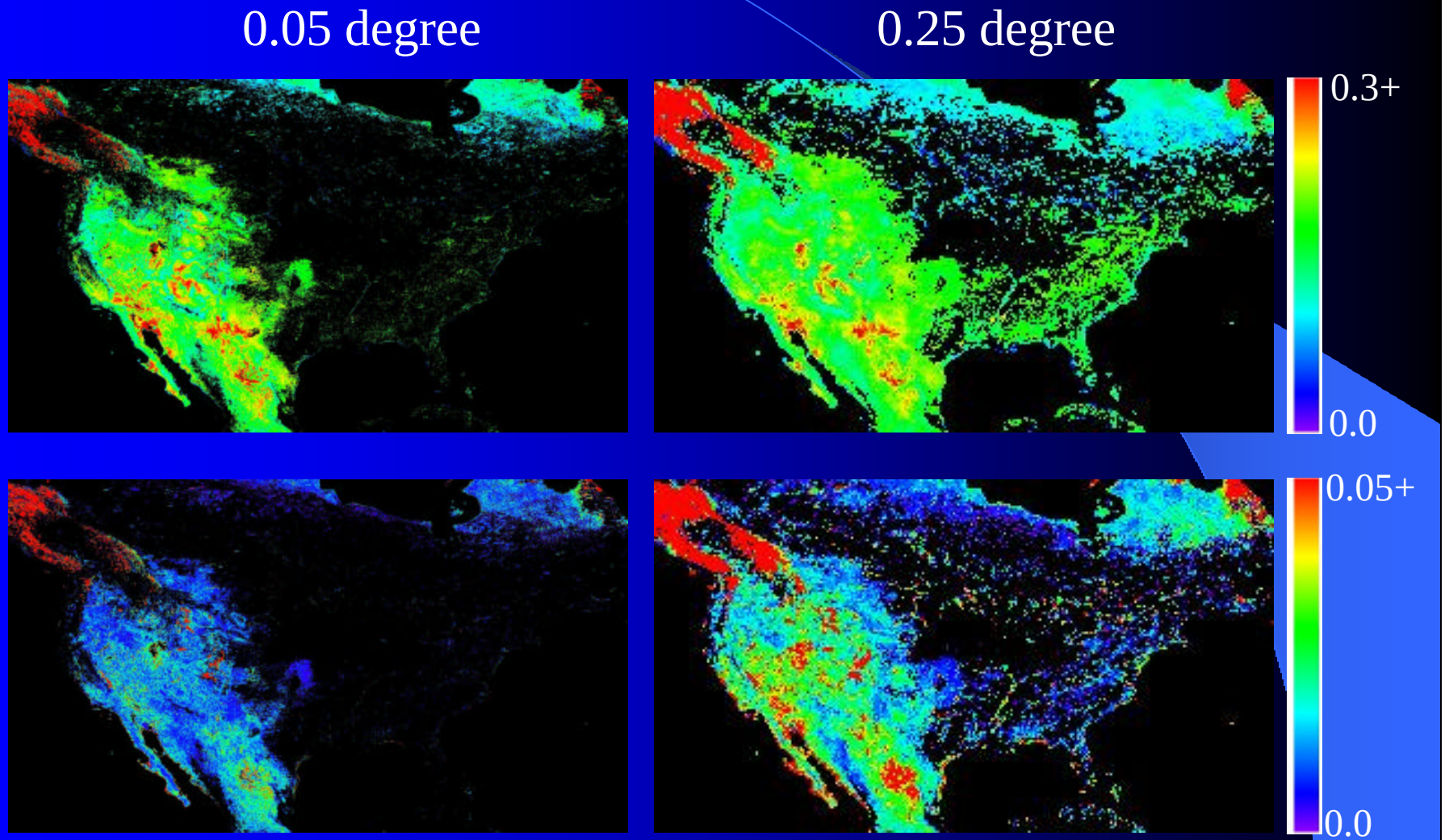
Shortwave White-sky Albedo Subgrid for Evergreen Needleleaf Forest (May 25 - June 9, 2001)



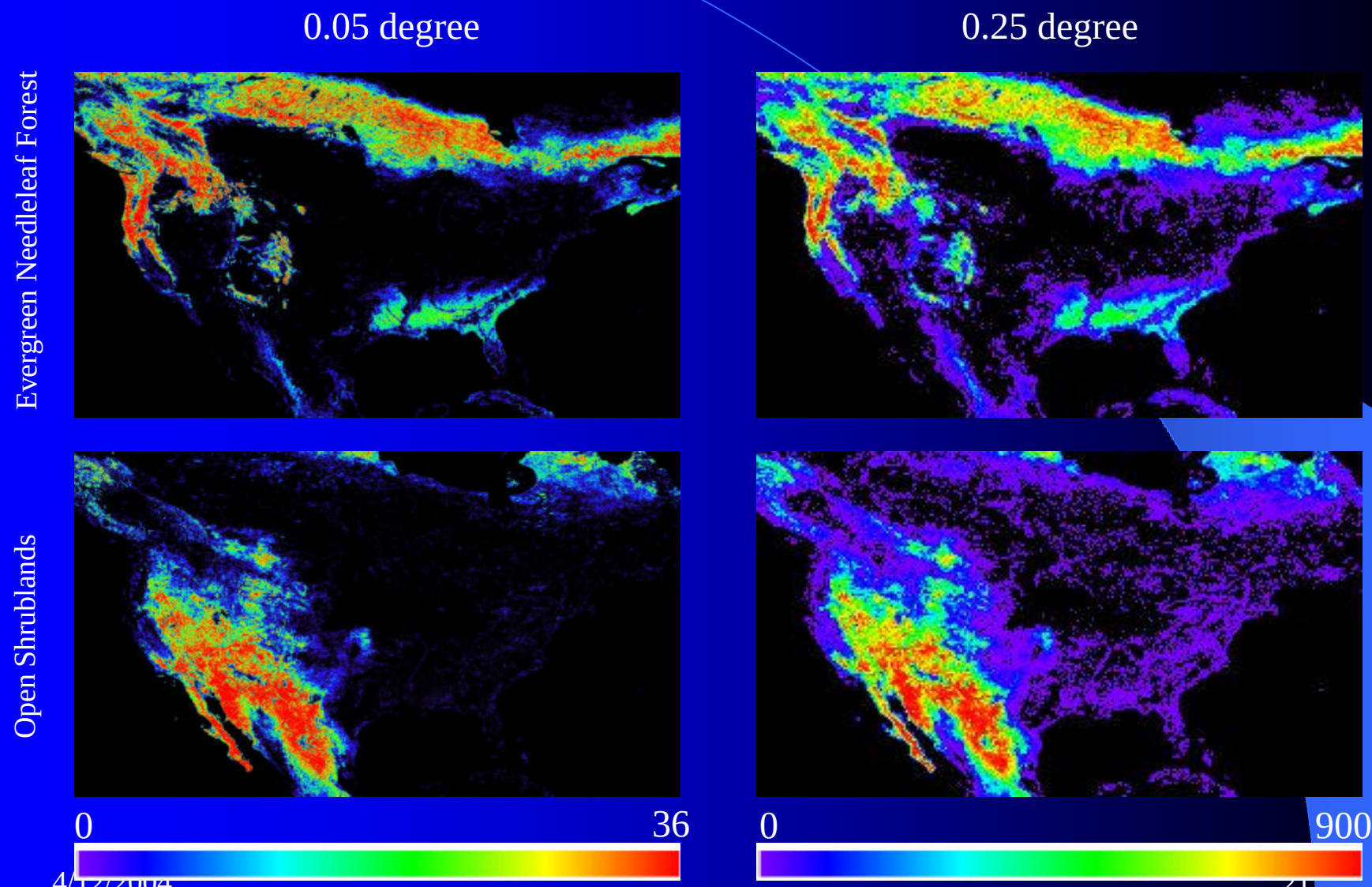
Shortwave White-sky Albedo Subgrid for Evergreen Needleleaf Forest (May 25 - June 9, 2001) Cont.



Shortwave White-sky Albedo Subgrid for Open Shrublands (May 25 - June 9, 2001)



Number of Pixels in Subgrid for Albedo Statistics (May 25 - June 9, 2001)



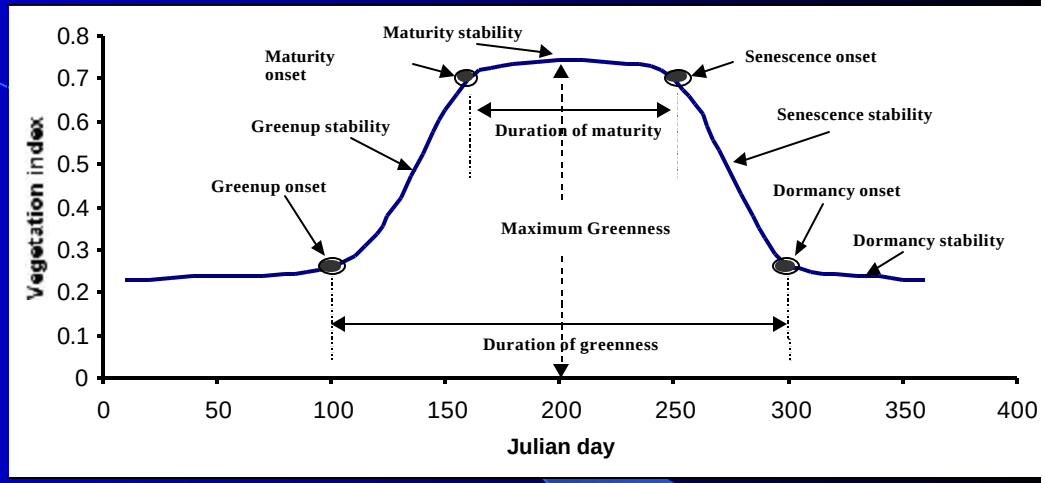
Project Activities 2: Estimating F_v from MODIS

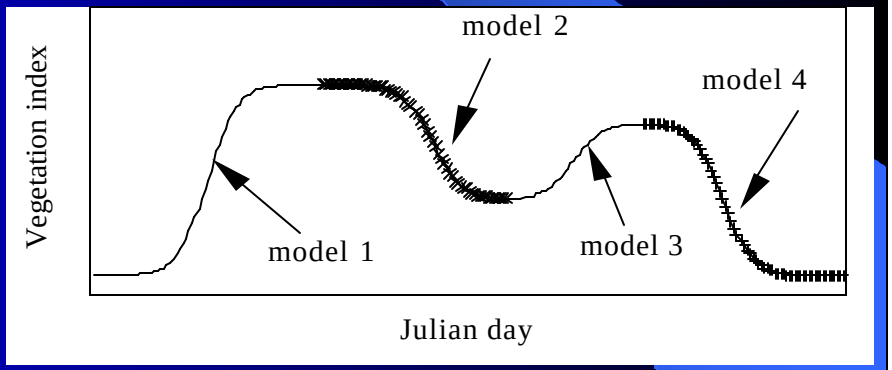
- Basic Definitions
  - F_v: fraction area covered with vegetation
  - F_g: Fraction of F_v that is green
- Current Approach
  - Use time trajectory of NDVI
  - Assume bare soil value ($NDVI_{min}$):

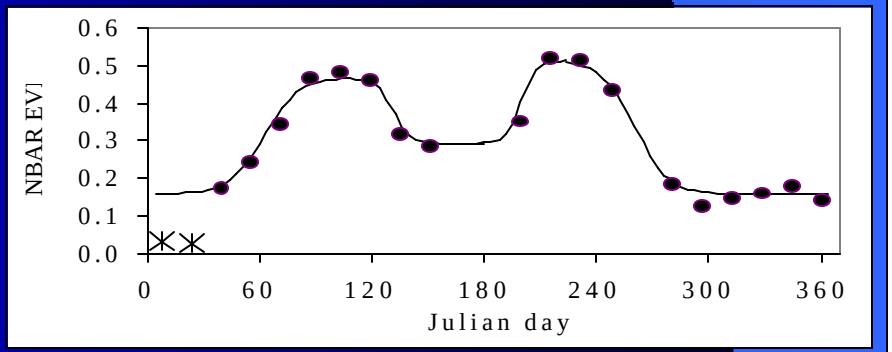
$$F_v(t) ? \frac{NDVI_t ? NDVI_{min}}{NDVI_{max} ? NDVI_{min}}$$

Approach

- Issue wrt current work
  - Use of fixed $NDVI_{min}$
  - Correlated with LAI
  - Variability caused by view geometry & soil background
  - Snow contamination
- Present Strategy:
  - Exploit MODIS phenology product
  - Soil resistant/view angle corrected vegetation index (NBARS EVI)



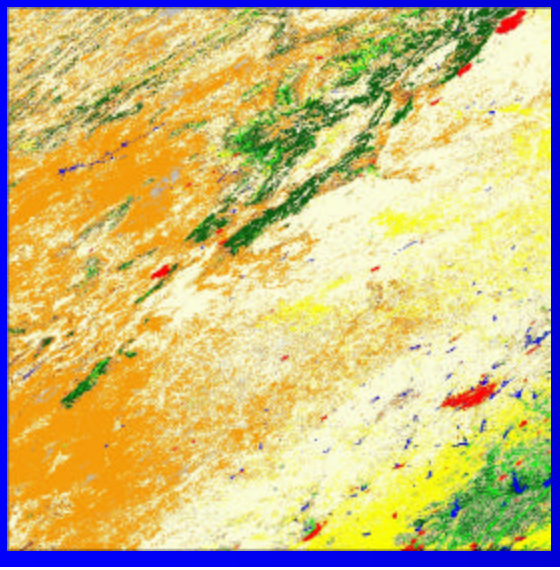


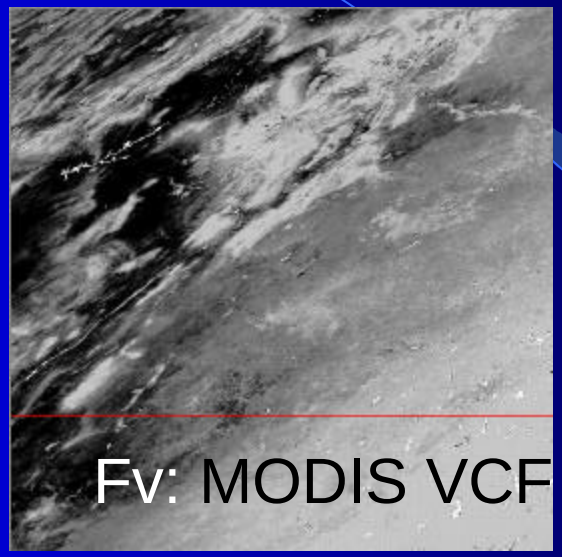


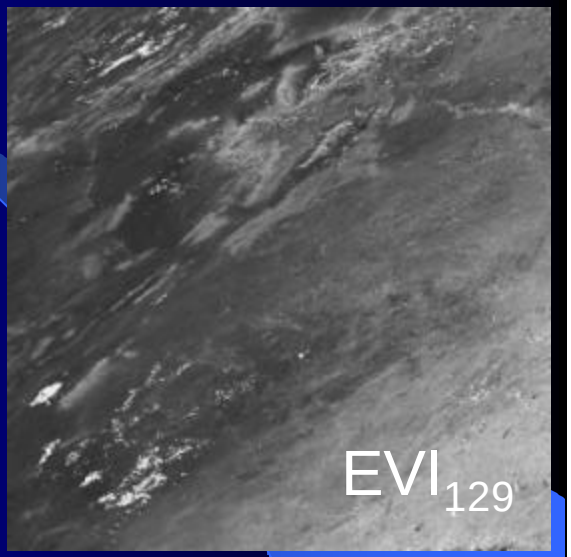
Southwestern US

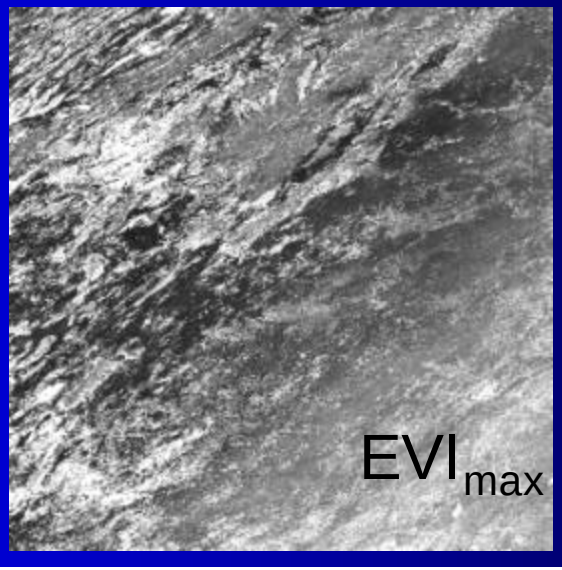
For this work:

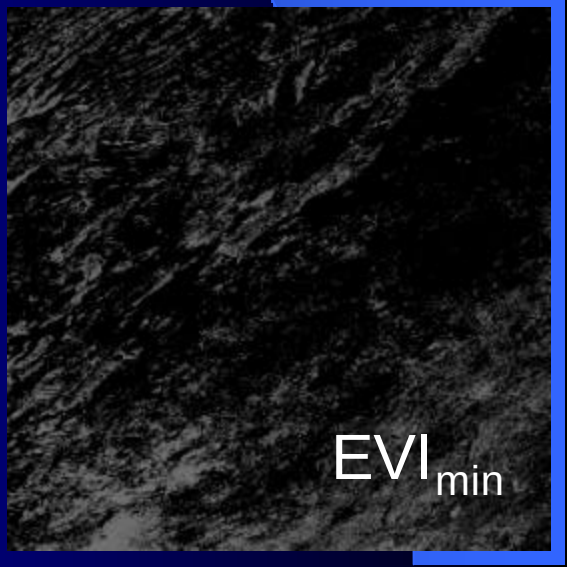
- Use EVI
  - Resistant to soil background
  - Exploit phenology

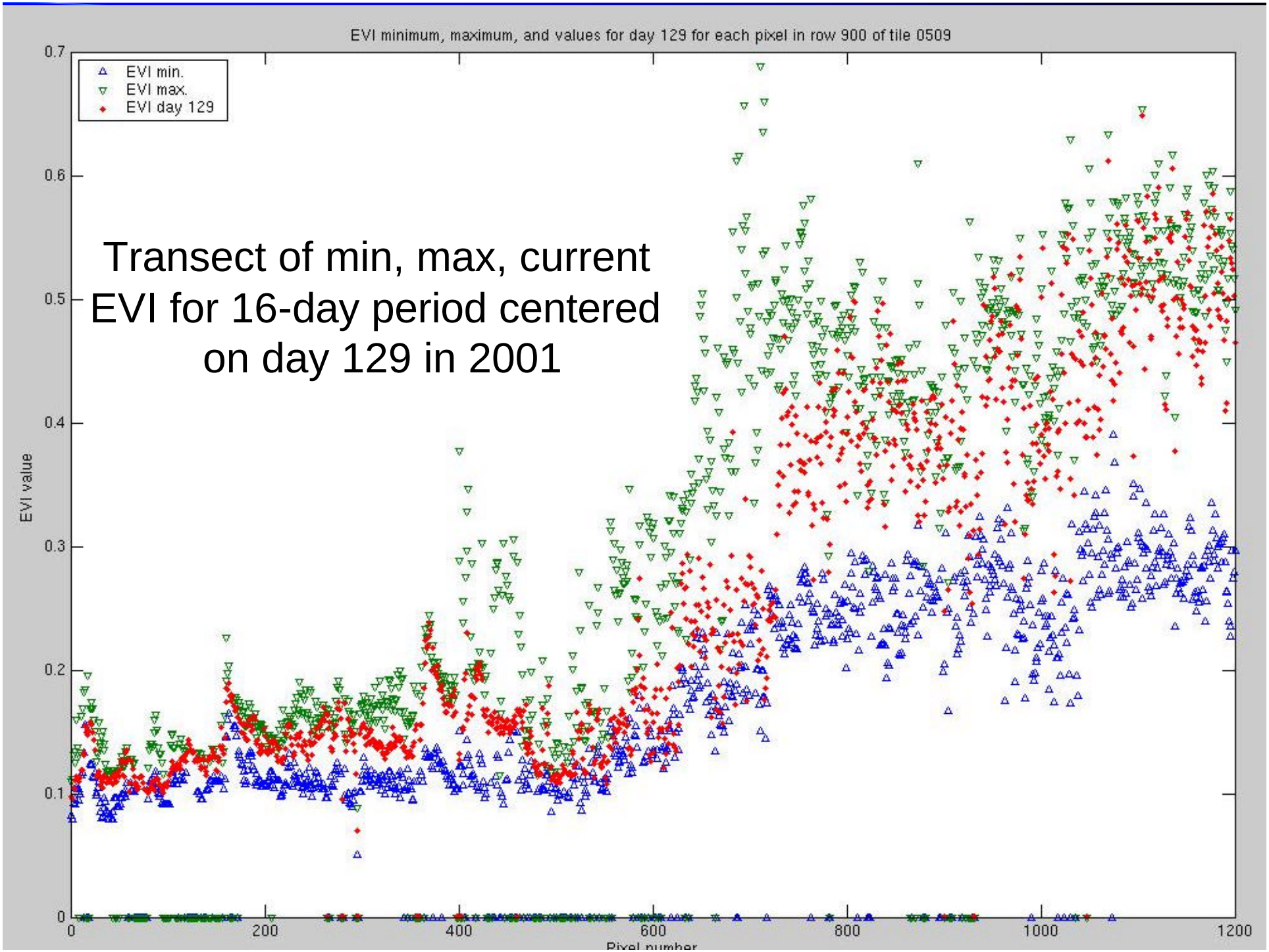












Transect of min, max, current EVI for 16-day period centered on day 129 in 2001

Basic Approach

- Stratify Land Cover into
  - Evergreen
  - Other
- For all evergreen $F_g = F_v$
  - Decouples LAI and F_v
- For deciduous vegetation:
  - Use historical database to define min-max range of EVI at each 1-km cell.
- Estimate F_g

$$F_g(t) ? \frac{EVI_t ? EVI_{\min}}{EVI_{\max} ? EVI_{\min}}$$

- Advantages
  - Exploits phenology database
  - No fixed “soil” NDVI
  - Uses “soil-resistant” EVI
  - NBARs accounts for view geometry

Assessment

- Baseline:
  - Comparison of MODIS products with heritage:
    - AVHRR
- Model assessment:
  - Quantify how MODIS inputs affect NCEP/WRF simulations
  - Offline sensitivity analysis
  - Coupled (online) simulations

Future Work

- Current Project
  - Deliver code and prototype data sets for North America for testing at NCEP
  - Finalize methodology for Fv; compare results with existing data sets.
- Future Activities
  - Development of retrieval strategies for albedo, F_v/F_g, LAI for near-real-time assimilation